REMARKS

Claims 1-40 remain in the application. Claim 1 is amended to emphasize distinctions over cited art. Claims 3, 12, 16, 23, 32, and 36 are amended to change the word "destroyed" to --changed--, as is paragraph 0078. Basis for this amendment is found in paragraphs 0068-0070, 0073-0076, 0078, 0097, 0111, and 0123, for example. The amendments to the specification and claims are made to be consistent with the use of "changed" in connection with the change in band gap. The change in the band gap energy is due to the action of one of the claimed mechanisms; as a mechanism is activated from a relatively conjugated state to a relatively non-conjugated state, the conjugation is changed, which thereby changes the band gap energy.

Applicants appreciate that the previous grounds of rejections have been overcome.

Claims 1-2, 15, and 20 are rejected under 35 USC 102(b) as being anticipated by newly-cited Gimzewski et al (U.S. Patent 6,031,756).

Gimzewski et al disclose a molecule layered medium and method for creating a pattern. Molecules are disclosed that can be attached to a substrate and switched between different stable and metastable conformations. At least one of these conformations is generated or stabilized by the proximity of the substrate. Further, a layered medium comprising such molecules is disclosed, and a method to switch such molecules in a controlled way is provided. The layered medium is said to be useful as resists for lithographic applications, data storage media, and a promoter of electron transfer between two media.

Applicants' independent Claim 1 is directed to an electric field activated molecular switch comprising a molecular system that has an electric field induced band gap change that occurs via one of the following mechanisms:

(1) molecular conformation change or an isomerization;

(2) change of extended conjugation via chemical bonding change to change the band gap; or

(3) molecular folding or stretching.

Dependent Claims 2, 15, and 20 depend from Claim 1.

The Examiner argues that Gimzewski et al disclose a molecular switch that switches conformation and has electronic states that can differ in their potential energy, wherein the potential energy diagram is characterized by potential minima. The Examiner also argues that the molecule has extended conjugation and that there are bonds around which the molecular groups can rotate, referring to Figure 3. The Examiner states that the application of an electric field brings about the switching and the application of a voltage brings about the switching. The Examiner states that the substrate shown in Figure 5b can have electrodes between which are attached the molecules. The Examiner states that in Figure 5c the molecular switch is shown between two surfaces, the substrate and the actuators. The molecular switches are said to have groups that can rotate around bonds. The Examiner points to Figures 1b and 1c as indicating that there can be stretching of bonds as one of the changes. The Examiner notes that Figure 5c shows the molecular switches sandwiched between electrodes 4 and 31 through which a voltage is applied to the molecular switch layer and that among the uses of the molecular switches are in data storage, "which would indicate memories".

Applicants submit that citation of Gimzewski et al against the instant claims is not appropriate for the following reasons:

Gimzewski et al's molecular system and Applicants' systems are totally different systems, even though both utilize molecular configuration or conformation changes influenced by an external force. Gimzewski et al's system involves a center unit (**1** in Figures 1a-b) with two or more legs (**3** in Figures 1a-b) moving upwards or downward toward the bottom electrode (**4** in Figures 1a-b] under the influence of external forces (usually mechanical or electrical mechanical forces exerted by a probe; see Figures 1a-c and the discussion associated therewith). In this case, the motion is rather like that of a jack-in-the-box, in that the two mechanical states available to the molecule are latched down (where the central part of the molecule is held down by the attractive force between the molecule and the substrate), and the unlatched state where the molecule is "standing up". The legs **3** used in their system will only provide bi-stability for the two molecular configuration states. Their configuration (or conformation changes), standing up or latched down, will not alter any electrical or optical properties of the center portion **1** of the molecule (or the entire molecule).

Gimzewski et al never mention nor claim that those legs contribute to the total conjugation (or electron delocalization) of the molecule, and they never mention nor claim that the conformation change will alter (or change) the electron-delocalization over the entire molecule, or the energy width of the molecular band-gap. In their system, they might observe some change of electrical conduction of the monolayer, but that is purely caused by the change of the electrical tunneling distance between the center unit **1** and the bottom electrode **4**, and nothing to do with the band-gap change, or change of electron delocalization, of the molecule.

In contrast, Applicants claim an electric field activated molecular switch comprising a molecular system that has an electric field induced band gap change that occurs via one of the following mechanisms:

(1) molecular conformation change or an isomerization;

(2) change of extended conjugation via chemical bonding change to change the band gap; or

(3) molecular folding or stretching.

As set forth in dependent Claims 3, 8, 12, and 16, there are two states achieved by any of these mechanisms under the influence of an applied electric field: a first state in which there is extended conjugation throughout the molecule, resulting in a relatively smaller band gap, and a second state in which the extended conjugation is changed, resulting in a relatively larger band gap.

Because of the relative conformation changes between one state and the other, the highest occupied molecular orbital (HOMO) and/or the lowest unoccupied molecular orbital (LUMO) can be delocalized over the entire molecule (the molecule is an electrical conductor), or they can become localized on one portion or different parts of the molecule (the molecule is an electrical resistor). As a result, the electron energy band-gap of the molecular system will change accordingly (e.g., small for the conductor state, and large for the resistor state).

Thus, Applicants rely on the switching between one of two energy states of the molecule, wherein in one state, the molecule is essentially fully conjugated and conducting and in the other state, the conjugation is changed and the molecule is a resistor. This is a fully reversible process.

Applicants' invention is directed to an intramolecular event that occurs in the presence of an electric field; this is not a redox or a chemical reaction. No net change in the numbers or types of atoms occurs and no net change in the number of electrons in the molecule occurs. The change in the band gap occurs with no addition or subtraction of anything (atoms, electrons, etc.), which is quite desirable to have; only a conformational change takes place.

As argued by Applicants in their previous Amendment filed February 15, 2005, the existence of the bipolar transistor hardly precluded patentability of the field effect transistor. Likewise, here, the existence of the switch of Gimzewski et al, which operates on one mechanism, cannot preclude patentability of Applicants' switch, which operates on a totally different mechanism. Specifically, there is not the slightest disclosure or suggestion by Gimzewski et al that their molecule, whether "rotating" about the bonds shown in Figure 3, or any other change, results in a change in the band gap of the molecule. (The "rotating" aspect of the Gimzewski et al molecule is discussed further below.) For example, the molecule in Figure 3 does not have extended conjugation in one rotational state and broken or reduced conjugation in another rotational state.

A condition of conjugation between two rings is that the rings must be planar with respect to each other. Without planar conformation, the pi electrons between the rings cannot overlap. The very essence of Applicants' aspect of their rotor-stator invention is the rotation of adjacent rings out of planarity to break conjugation between the rotor and stators.

The porphyrin ring and its peripheral benzene rings provided in the teachings of Gimzewski et al are incapable of a planar conformation. Gimzewski et al admit this in line 8, column 10 by describing the potential switched conformation of the porphyrin and benzene rings as "***almost*** parallel" (emphasis added). In a planar state, the hydrogen atoms of the porphyrin and each benzene ring fully overlap in two places. In its natural state, however, the repulsion of the hydrogen atoms orient each benzene ring out of plane with the porphyrin by approximately 90 degrees. It is this interference to planarity that allows Gimzewski et al to space the porphyrin away from the substrate by way of the maximally out-of-plane benzene rings. In this con-

nection, note Fig. 1a in combination with Fig. 3 to see the peripheral entities ("legs") **3** perpendicular to the central entity (porphyrin ring) **1**.

The point here is that Gimzewski et al do not teach molecular design in which one switch state is conjugated while the other is less conjugated. In their example, there is no change in conjugation between switch states. Molecular models done here suggest that to orient Gimzewski et al's benzene rings within 20 degrees of planarity will require 19 kcal/mole energy. It is difficult to couple more than about 2-3 kcal/mole of energy with an electric field that remains below the dielectric strength of most materials. Moreover, Gimzewski et al do not teach the inclusion of high dipole materials capable of strongly coupling his "switch" into an electric field.

Not only does Gimzewski et al fail to teach a change in conjugation, their molecules are designed ***away*** from conjugation. Fig. 3 is essentially a 2-dimensional projection, to show the details of the molecule, but there should not be any inference that the molecule is coplanar throughout; see, Fig. 1a. Indeed, even in the second "state" of Gimzewski et al, co-planarity is not achieved, as argued above, and as shown in Fig. 1b.

Applicants point out:

(a) There is no description of a band gap change induced by an electric field in any of the paragraphs the Examiner quoted in Gimzewski et al's patent. Gimzewski et al's system relies on a jack-in-the-box type of motion, where the legs are essentially springs that cause the central portion of the molecule to pop up if triggered by some mechanical or electrical stimulus, and if pushed down the molecule sticks to the substrate because of various types of binding forces. Applicants respectfully request that the Examiner specifically point out in Gimzewski et al where there is any disclosure or suggestion that their molecular system includes a portion that undergoes rotation or that there is a change in electron localization/delocalization (non-conjugation/conjugation). The legs **3** in Figs. 1a-1b are the same as shown in Fig. 3. The Examiner is apparently assuming that these moieties **3** in Fig. 3 can freely rotate, but it is clear from Figs. 1a-1b that they "adhere to a substrate **4**" (Col. 8, lines 64-66).

(b) Elements **18** and **19** in Gimzewski et al's patent represent two different molecular configuration states (Col. 9, lines 9-15). There simply is no disclosure or suggestion by Gimzewski et al to support the Examiner's position. Indeed, all

that occurs is movement of the central entity **1** toward and away from the substrate **4**, due to the sideways tilting of the peripheral entities **3**. Tilting is ***not*** rotation.

(c) In Gimzewski et al's patent, they only describe that their molecular system can be switched from one conformation state **18** to another **19**. They never mention or claim that any band gap or electrical properties of the molecular system changed due to those conformation changes. Molecular conformation change does not necessary change the electrical conduction properties of the molecular system. It is really dependant on the design of the specific molecular system. The assumption that any molecular configuration or conformation change will automatically change the conduction properties or band gap of the molecules is incorrect. In Gimzewski et al's system, the molecular conformation or configuration change only changes the relative distance of the center unit **1** toward the bottom electrode **4**, and ***not*** any change in their electronic properties or band gap of the molecules. Molecular electronic properties or band gap will change with the change of molecular conformation ***only*** if the switchable portion of the molecule belongs to a completely conjugated system in one of their stable conformation states, and p- and π-electrons can be delocalized through the entire molecular system.

(d) Even though in Gimzewski et al's patent, they disclose and claim E-field induced conformation change of their molecules, this should in no way bar Applicants from claiming that molecular band gap and electrical conduction changes due to their molecular conformation change or isomerization occur in certain types of molecular systems.

(e) Gimzewski et al state that "[t]he peripheral entities **3** are able to rotate around these C-C axes, the average tilt angle being the relevant configurational coordinate of this molecule" (col. 9, lines 65-67). For example, Figures 1a and 1b show the simple tilting of the center entity **1** with respect to the peripheral entities **3**. This is supported by the continuing discussion on col. 10, lines 1-10, regarding rotation of the peripheral entities **3** out of the drawing plane by an angle of 90 degrees around the C-C axis (conformation **18**) and into the drawing plane (conformation **19**), with reference to Figs. 1a-1b. This type of motion is similar to that exhibited by a jack-in-the-box.

Indeed, Applicants assert that Gimzewski et al have mis-used the term "rotation"; the motion they describe is more appropriately termed "bending" or "tilting".

In this connection, compare Figs. 1a and 1b, which depict the molecule in two different "states". The Gimzewski et al patent is all about designing clever molecules that will pop up and down on a surface, like a jack-in-the-box. The two states of the molecule (or molecular conformations) are bistable with respect to each other. In each case, Gimzewski et al describe a molecule with a large planar part **1** that is parallel to a surface, and which is held above the surface by a set of legs **3**. In the down position or conformation of the molecule, van der Waals or other forces hold the large planar part of the molecule close to the underlying substrate, and the legs are strained or twisted to allow the planar part of the molecule to touch the substrate. In the up position, the legs straighten out and lift the planar part of the molecule away from the surface. The molecule shown in Fig. 3 and described in Col. 9, line 57 to Col. 10, line 10 of Gimzewski et al is actually not consistent with the general diagram of the invention shown in Fig. 1; however, one experienced in this art can figure out how this molecule is supposed to work. The large central porphyrin group **1** of the molecule in Fig. 3 is the part that pops up and down from the surface of the substrate. The molecule has four legs **3**, which are essentially ellipsoidal appendages on the central part. By exerting a force down on the central part of the molecule, the four legs tilt around the chemical bonds, connecting them to the central portion of the molecule to effectively shorten them. When the central portion of the molecule is pushed close enough to the surface, it locks into place because of the van der Waals attraction between the surface and the planar part of the molecule. If there is an electronic switch action, it occurs because the planar part of the molecule is physically closer to the surface. In this process, the conformation of the molecule changes, but this conformational change is irrelevant to the intrinsic electronic conductivity perpendicular to the plane of the molecule - that issue was never even mentioned in the patent of Gimzewski et al.

In the present patent application, the situation is completely different. Here, a switch molecule bridges between two electrodes (it is roughly perpendicular to the surfaces of both electrodes). Because of the specific design of the molecules, a change via one of the listed mechanisms causes the entire electronic configuration of the molecule to change. In one case, the electric current-carrying molecular orbitals are delocalized over the entire molecule, and thus electric current will flow along the length of the molecule (parallel to the molecular axis) from one electrode to the other.

In the other case, the molecular orbitals are localized on specific parts of the molecules and thus current does not readily flow through the molecule. The change in the electronic current carrying state is known in the chemical literature as delocalization/localization and in the physics literature as the narrowing or widening of the band gap of the molecules. This effect occurs as a consequence of altering the conjugation of the molecule; in a fully conjugated molecule, the molecular orbitals are delocalized, while in a molecule where the conjugation is changed, such as by one of the mechanisms 1-3 of Claim 1, the molecular orbitals are localized.

Summarizing, Applicants respectfully request that the Examiner point out specific citations in Gimzewski et al that (1) teach bi-stable behavior based on conjugated/non-conjugated transformations, and (2) teach, as a result of (1), delocalization/localization of electrons over the molecular system, and thus a change in the electronic conductivity of the molecule. Applicants assert that the Examiner will be unable to show the foregoing, and further, that the Examiner will be unable to find any portion of the reference that even remotely suggests any of the foregoing. Indeed, the example molecule in Fig. 3 of Gimzewski et al is incapable of conjugation-deconjugation switching, regardless of the assertion by the Examiner, and the potential energy curves of Figs. 4a-4b infer nothing whatsoever about any electric field induced band gap change in the molecule. Accordingly, Applicants expect that the Examiner will withdraw this rejection.

Reconsideration of the rejection of Claims 1-2, 15, and 20 under 35 USC 103(b) as being unpatentable over Gimzewski et al is respectfully requested.

Claims 3, 6-8, 11, 12, 16, 18, 19, 21-23, 26-28, 31-32, 35, 36, and 38-40 are rejected under 35 USC 103(a) as being unpatentable over Gimzewski et al, *supra*, in view of previously-cited Heath et al (U.S. Patent 6,198,655).

The Gimzewski et al reference is discussed above. The Heath et al reference, which was the subject of Applicants' previous Amendment, disclose electrically addressable volatile and non-volatile molecular-based switching devices. The molecular devices include certain [2] catenanes as bistable molecules which are sandwiched between two switch terminals. The switches are said to be extremely small and have dimensions which range from several microns down to a few nanometers. This refer-

ence is quite similar to U.S. Patent 6,459,095, cited in paragraph 0002 in its disclosure of catenanes.

The Examiner admits that Gimzewski et al are silent with respect to the recited limitations of the claims with respect to the first and second states and the relationship to the rotor portion and with respect to the junction as recited in the claims. However, the Examiner argues that

> "it would have been obvious to one of ordinary skill in the art at the time of the invention from Fig. 3 and relating Fig. 3 to Fig. 4a and Fig. 4b that there are rotor portions of the molecule as shown in Fig. 3 and that this can also be a mechanism of raising the molecule to an excited state".

The Examiner then adds "as is well known in the art that there can be pi-bond breaking and forming as part of the conformation changes".

Applicants have discussed Heath et al extensively in their previous Amendment. Essentially, Applicants showed that Heath et al disclose and claim reduction-oxidation (redox) reactions to effect switching, whereas Applicants' invention is directed to an E-field induced molecular conformation change via a ***non***-redox process. If the Examiner is arguing that it is reasonable to combine Gimzewski et al and Heath et al, then this implies that Gimzewski et al must also be directed to a redox process. Otherwise, the combination of a non-redox process and a redox process would be untenable. In this case, two redox references combined would still not disclose or suggest Applicants' non-redox process, and the rejection falls.

If, on the other hand, Gimzewski et al are directed to a non-redox process, as implied from the Examiner's comments regarding the 102 rejection, then the combination is clearly untenable, for how would one combine two references disclosing entirely different mechanisms.

Either Applicants' claims are unpatentable over Gimzewski et al or over Heath et al, but not over a combination of both. As shown in Applicants' previous Amendment, Heath et al cannot render Applicants' claims unpatentable, due to the entirely different switching mechanism.

With regard to the rotor aspect of Applicants' claimed invention, Applicants claim an extended conjugated molecular system containing at least one stator portion and at least one rotor portion, wherein the rotor rotates from a first state to a second

state with an applied electric field (Claims 3 and 23). The Examiner is attempting to read more into Gimzewski et al than is warranted. From his remarks, the Examiner appears to be arguing that items **3** of Fig. 3 can fully rotate about the bonds **2** connecting them to the porphyrin structure **1**. However, this is an inappropriate interpretation, in light of the plain teachings of the reference. Specifically, in Figs. 1a and 1b, items **3** are merely supporting legs, adhered to the substrate, that can bend to the side, but do not rotate about the bonds **2**.

Applicants' rotor can rotate under the influence of an external E-field, and the stator portions will not change with the external E-field. Because of the relative conformation changes between the rotor and stator portions, the highest occupied molecular orbital (HOMO) and/or the lowest unoccupied molecular orbital (LUMO) can be delocalized over the entire molecule, i.e., over the rotor and both stators (the molecule is an electrical conductor), or they can become localized on one portion or different parts of the molecule (the molecule is an electrical resistor). As a result, the electron energy band gap of the molecular system will change accordingly (e.g., small for the conductor state and large for the resistor state).

Thus, Applicants rely on the ***rotation*** of a rotor between, for example, two stationary stators to switch between one of two energy states of the molecule, wherein in one state, the molecule (stator-rotor-stator) is essentially fully conjugated and conducting and in the other state, the conjugation is changed and the molecule is a resistor. This is a fully reversible process.

Applicants point out:

(a) There is no description of a rotor or stators in any of the paragraphs the Examiner quoted in Gimzewski et al's patent. As discussed above, Gimzewski et al's system relies on a jack-in-the-box type of motion.

(b) Elements **18** and **19** in Gimzewski et al's patent represent two different molecular configuration states (Col. 9, lines 9-15); they are not rotor or stator portions of the molecules. Indeed, all that occurs is movement of the central entity **1** toward and away from the substrate **4**, due to the sideways tilting of the peripheral entities **3** ("jack-in-the-box" motion). Tilting is ***not*** rotation.

(c) In Gimzewski et al's patent, they only describe that their molecular system can be switched from one conformation state **18** to another **19**. Of course,

for such a system, there would be maxima and minima in the energy of the molecule with the conformation changes. However, this in no way would suggest to one skilled in the art that an electric field induced band gap change is taking place. The comments made above regarding switching from one conformation state to another obtain here as well, as do the aspects discussed in items (d) and (e) above.

With respect to the Examiner's statement regarding the pi-bond breaking and forming in the art, that may be true, but neither Gimzewski et al nor Heath et al disclose the making and breaking of pi-bonds. To assert otherwise is to read more into these references than is warranted and to engage in hindsight reconstruction of a facsimile of Applicants' claims, based on their own disclosure.

Reconsideration of the rejection of Claims 3, 6-8, 11, 12, 16, 18, 19, 21-23, 26-28, 31-32, 35, 36, and 38-40, as amended, under 35 USC 103(a) as being unpatentable over Gimzewski et al in view of Heath et al is respectfully requested.

Applicants appreciate that Claims 4, 5, 9, 10, 13, 14, 17, 24, 25, 29, 30, 33, 34, and 37 would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. However, based on the foregoing arguments, Applicants assert that the remaining claims are also allowable.

The foregoing amendments and arguments are submitted to place the application in condition for allowance. The Examiner is respectfully requested to take such action. If the Examiner has any questions, the Examiner is invited to contact the undersigned at the below-listed telephone number. HOWEVER, ALL WRITTEN COMMUNICATIONS SHOULD CONTINUE TO BE DIRECTED TO: IP ADMINISTRATION, LEGAL DEPARTMENT, M/S 35, HEWLETT-PACKARD COMPANY, P.O. BOX 272400, FORT COLLINS, CO 80527-2400.

Respectfully submitted,

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